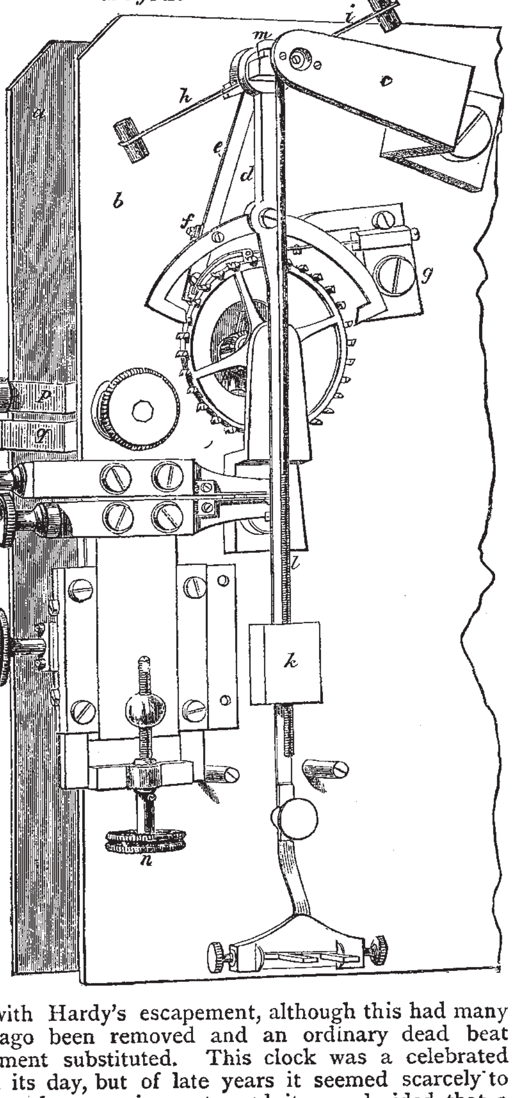
about forty in the great Pipe-fish (*Syngnathus acus*). In illustration of the amount of force expended in the working of its propeller, it may be mentioned that Prof. Lankester finds that it is only in the above-described muscles, by which it is moved, and in no other part of the body, that the red-colouring haemoglobin is to be detected.

THE NEW STANDARD SIDEREAL CLOCK OF THE ROYAL OBSERVATORY, GREENWICH

THE Royal Observatory at Greenwich has lately acquired a new standard sidereal clock which possesses several peculiarities of construction. The one formerly in use was that made by Hardy, and originally

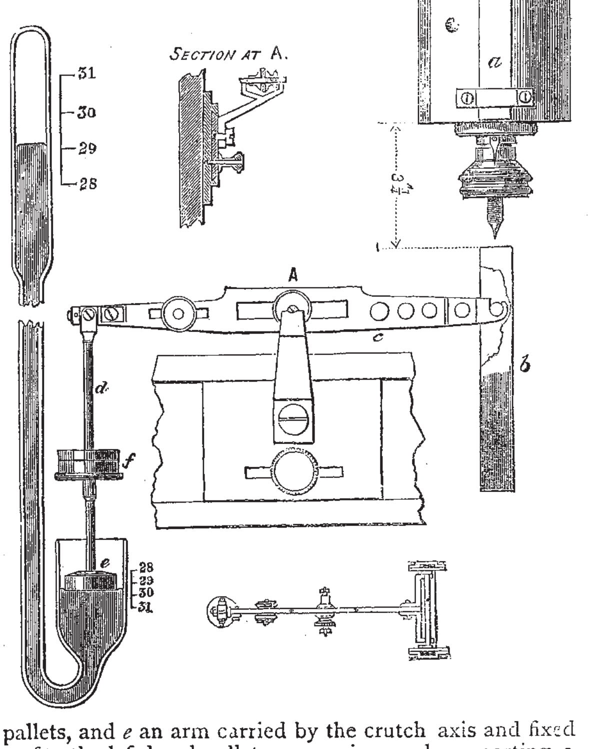
Fig. 1.



fitted with Hardy's escapement, although this had many years ago been removed and an ordinary dead beat escapement substituted. This clock was a celebrated one in its day, but of late years it seemed scarcely to satisfy modern requirements, and it was decided that a new one should be constructed. This has now been done. The new clock was planned generally by the Astronomer Royal, and constructed entirely by Messrs. E. Dent and Co., of the Strand. It was completed and brought into use in the year 1871, and both as regards quality of workmanship and accuracy of performance it appears to be an excellent specimen of horological art. As in the galvanic system of registration of transit observations it is unnecessary that the clock should be within hearing or view of the observer, the new clock has been fixed in the Magnetic Basement, in which the temperature varies only a very few degrees during the course of a year.

The pendulum is supported by a large and solid brass casting securely fixed to the wall of the basement, and the clock movement is carried by a platform forming part of the same casting. The Astronomer Royal adopted a form of escapement analogous to the detached chronometer escapement, one that he had himself many years before proposed for use,* in which the pendulum is free, excepting at the time of unlocking the wheel and receiving the impulse. Several clocks having half-seconds pendulum had since been made with escapement of this kind, but the principle had not before been applied to a large clock. The details of the escapement may be seen in Fig. 1, which gives a general view of a portion of the back plate of the clock movement, supposing the pendulum removed: *a* and *b* are the front and back plates respectively of the clock train; *c* is a cock supporting one end of the crutch axis; *d* is the crutch rod carrying the

Fig. 2.



pallets, and *e* an arm carried by the crutch axis and fixed at *f* to the left-hand pallet arm; *g* is a cock supporting a detent projecting towards the left and curved at its extreme end; at a point near the top of the escape wheel this detent carries a pin (jewel) for locking the wheel, and at its extreme end there is a very light "passing spring." The action of the escapement is as follows:— Suppose the pendulum to be swinging from the right hand. It swings quite freely until a pin at the end of the arm *e* lifts the detent; the wheel escapes from the jewel before mentioned, and the tooth next above the left-hand pallet drops on the face of the pallet (the state shown in the figure) and gives impulse to the pendulum; the wheel is immediately locked again by the jewel, and the pen-

* In the year 1827, in a paper "On the Disturbances of Pendulums and Balances, and on the Theory of Escapements," which appears in the third volume of the *Transactions of the Cambridge Philosophical Society*.

dulum, now detached, passes on to the left; in returning to the right, the light "passing spring" before spoken of allows the pendulum to pass without disturbing the detent; on going again to the left, the pendulum again receives impulse as already described. The right-hand pallet forms no essential part of the escapement, but is simply a safety pallet designed to catch the wheel in case of accident to the locking-stone during the time that the left-hand pallet is beyond the range of the wheel. The escape wheel carrying the seconds hand thus moves once only in each complete or double vibration of the pendulum, or every two seconds.

An ordinary mercurial seconds pendulum was first constructed, with jar of larger diameter than is usually made, but this did not give satisfactory results. Notably it was found, whilst still on trial in the workshop, that when the temperature of the apartment was raised, the clock increased considerably its losing rate, which only slowly returned towards its previous value, showing quick action on the rod and slow action on the quicksilver. This pendulum was finally discarded and another made employing entirely a metallic compensation. A central steel rod is encircled by a zinc tube resting on the rating nut on the steel rod; the zinc tube is in its turn encircled by a steel tube which rests at its upper end on the zinc tube, and carries at its lower end the cylindrical leaden pendulum bob attached at its centre to the steel tube. The weight of the bob is about twenty-six pounds. Slots are cut in the outer steel tube, and holes are made in the intermediate zinc tube, so as better to expose the inner parts of the compound pendulum rod to the action of temperature. For final adjustment of the compensation two straight compensated brass and steel bars (*h* and *i* in the figure) are carried by a collar, holding by friction on the crutch axis, but capable of being easily turned on the axis. The bars carry small weights at their extremities, as shown. Increase of temperature should accelerate or retard the clock according as the brass or steel lamina is respectively uppermost. The bars were at first placed in the upright (neutral) position, and it is anticipated that, by turning them into an inclined position as respects the pendulum rod, power will be given within a certain limit (reached when the bars stand horizontal) of correcting any defect in the primary compensation, but, on account of the uniform temperature of the Magnetic Basement, no opportunity has yet arisen for testing the efficiency of the apparatus. A contrivance is also added with the object of making very small changes of rate without stopping the pendulum. A weight *k* slides freely on the crutch rod, but is tapped to receive the screw cut on the lower portion of the spindle *l*, the upper end of which terminates in a nut *m* at the crutch axis. By turning this nut the position of the small weight on the crutch rod is altered, and the clock rate correspondingly changed. To make the clock lose, the weight must be raised.*

In the arrangement of the going power the ratchet is so constructed that it does not touch the great wheel on its flat part, with the object of avoiding unnecessary friction when the maintaining spring alone is acting. The driving weight of the clock is about $5\frac{1}{4}$ lb., and in order to avoid sympathetic vibration, it is made to descend in a compartment of the clock-case separate from that containing the pendulum; it also bears slightly against the side of the compartment.

The brass vertical sliding piece shown at the lower left-hand side in Fig. 1 carries at its upper end two brass bars, each of which has at its right-hand extremity, between the jaws, a slender steel spring for galvanic contact; the lower spring carries a semicircular piece projecting downwards, which a pin (jewel) on the crutch rod lifts in passing, bringing the springs in contact at each vibration (these parts are concealed in the figure by the crutch rod); the contact takes place when the pendulum is vertical, and the acting surfaces of the springs are, one platinum, the other gold, an arrangement that has been supposed to be preferable to making both surfaces of platinum. By means of the screws *n* and *o*, which both act on sliders, the contact-springs can be adjusted in the vertical and horizontal directions respectively. Other contact-springs in connection with the brass bars *p q* on the other side of the back plate are ordinarily in contact, but the contact is broken at *one* second in each minute by an arm on the escape-wheel spindle. The combination of these contacts permits the clock to complete a galvanic circuit at fifty-nine of the seconds in each minute, and omit the sixtieth, for a purpose to be hereafter mentioned.

No contrivance was originally applied to the clock for correction of the barometric inequality, but the clock had not been in use many months before the extreme steadiness of its rate otherwise brought out with marked distinctness the existence of the inequality. It was easily seen that for a decrease of one inch in the barometer reading, the clock increased its daily gaining rate by about three-tenths of a second. The Astronomer Royal eventually arranged a plan for correction of the inequality, founded on the magnetic principle long previously in use at the Royal Observatory for daily adjustment of the mean solar standard clock, and the apparatus has been applied to the clock by Messrs. Dent. Two bar magnets, each about six inches long, are fixed vertically to the bob of the clock pendulum, one in front (shown at *a*, Fig. 2), the other at the back. The lower pole of the front magnet is a north pole; the lower pole of the back magnet is a south pole. Below these a horseshoe magnet, *b*, having its poles precisely under those of the pendulum magnets, is carried transversely at the end of the lever *c*, the extremity of the opposite arm of the lever being attached by the rod *d* to the float *e* in the lower leg of a syphon barometer. The lever turns on knife edges. A plan of the lever (on a smaller scale) is given, as well as a section through the point A. Weights can be added at *f* to counterpoise the horseshoe magnet. The rise or fall of the principal barometric column correspondingly raises or depresses the horseshoe magnet, and, increasing or decreasing the magnetic action between its poles and those of the pendulum magnets, compensates, by the change of rate produced, for that arising from variation in the pressure of the atmosphere. As the clock gained with low barometer, it was necessary to place the magnets so that there should be attraction between the adjacent ends; that is, that they should be dissimilar poles. One other point may be mentioned in connection with this apparatus. The cistern in which the float rests is made with an area four times as great as that of the upper tube; so that for a change of one inch of barometer reading, the horseshoe magnet is shifted only two-tenths of an inch, whilst the average distance between its poles and those of the pendulum magnets is about $3\frac{3}{4}$ inches: that is to say, the extent of variation of the position of the horseshoe magnet should be a small fraction of the whole distance, because, with this condition, the effect produced on the rate by equal increments of distance is then practically uniform. The action of the apparatus on the Greenwich clock has, as regards correction of the inequality of rate, been quite successful; and further, the extent of the pendulum arc, which was before subject to a slight variation, is now very constant, and amounts (the total arc) to about $2^\circ\ 33'$ with scarcely any change.

This account of the clock will scarcely be complete without some brief description of the use made of it. It has been mentioned that the clock completes a galvanic circuit fifty-nine times in each minute, but omits the

* As regards the efficiency of the zinc and steel compensation, it may be here mentioned that the transit clocks made for the Transit of Venus Expeditions were provided with pendulums compensated in this way. Some of these clocks underwent very severe trial at Greenwich before the various expeditions set out, with most satisfactory results. They seemed, indeed, to be superior to clocks fitted with the ordinary mercurial compensation.

sixtieth contact. The currents thus obtained (a small battery only being used on the clock) are used to work a relay from which three independent currents from other batteries are derived. One acts upon the seconds magnet of the chronograph for impress of seconds punctures on the paper on the revolving cylinder. The omission of one second in each minute marks with certainty the commencement of the minute. Observations at all the fundamental instruments are registered on this cylinder, and comparisons of clocks are thus entirely avoided. Another current regulates a half-seconds chronometer on the eye-end of the Great Equatoreal. The third current regulates the pendulum of a half-seconds clock in the Great Equatoreal Room, drives a tapper to make audible the seconds of the clock, and drives also a galvanic chronometer placed in the Computing Room for use in the daily work of comparing and setting to time the mean solar standard clock. The omission of one current in each minute is unimportant as concerns the regulated chronometer and clock, but not so as regards the chronometer which is driven by the current. To accommodate the chronometer to this state of things, its seconds wheel is cut with fifty-nine teeth only, and its seconds circle on the dial correspondingly divided into fifty-nine equal parts. The resting of the hand during one second, which takes place at a particular division of the dial, consequent on the loss of one current in each minute, is therefore compensated for by this construction of the seconds wheel and engraved dial plate.

ARCTIC VEGETATION

A FEW notes on the vegetation of the Arctic regions may not be out of season at the present time. For fuller details we may refer to Dr. Hooker's exhaustive essay on the distribution of Arctic plants, published in the Transactions of the Linnean Society, vol. xxiii., 1862. Since the appearance of this article very little has been added to our knowledge of Arctic vegetation, if we except the flora of Spitzbergen. Several naturalists have since visited the islands of this group, and about thirty additional species of flowering plants have been discovered. The greater part of these additions have been published in the *Journal of Botany*, vol. ii. pp. 130 to 137 and 162 to 176, and vol. i., series 2, p. 152; but a few interesting plants new to the group, collected by the Rev. Mr. Eaton, and now in the Herbarium at Kew, do not appear to have been published. With the exception of the shores of Smith's Sound in North America, Spitzbergen is the most northerly land yet trodden by the foot of restless explorers, and from its relative accessibility its vegetation is perhaps better known than any other part lying far within the Arctic circle. For this reason, and on account of their high latitude, we have chosen the vegetation of the Spitzbergen Islands to illustrate the whole flora of the Arctic regions. We have been influenced in this choice, too, by the fact that many of the species there represented are indigenous in Britain. Most of these species, it should be stated, are confined to the mountains of the north of England and Scotland.

To give a general idea of the whole flora of the North Frigid Zone, we may quote a few of Dr. Hooker's figures. By way of explanation it should be mentioned that Dr. Hooker takes a very broad view of species, and many forms considered as distinct species by some botanists here count as varieties. The more recent additions to the flora of Spitzbergen would not materially alter these figures, because the same species were all, or nearly all, previously known to exist in Arctic Continental Europe or America. A few deductions would also probably have to be made. For instance, the Reed-mace, *Typha*, appears to have been included by mistake in the list of Arctic American plants. The total number of species of flowering plants—with which alone we shall concern ourselves—given, is 762, o which about fifty are exclusively confined to the Arctic regions. A very large proportion of these are found in Scandinavia, south of the Arctic circle, and reappear in the Alps; a few reach the Alpine regions of the mountains of India and Africa, and a few reappear in the extreme south of the southern hemisphere. In a less degree the same thing occurs from north to south on the American continent. Of these 762 species, 616 have been observed in Arctic Europe, 233 in Arctic Asia, 364 in Arctic West America, 379 in Arctic East America, and 207 in Arctic Greenland. From the proportions the respective figures for the five different areas bear to the total, it will be seen that nearly all the areas must have a majority of species in common, and that each area has very few species peculiar to itself. Before proceeding to give a sketch of the flora of Spitzbergen, there is one remarkable fact deserving of special notice. Of the 207 species found in Greenland, 195 are Scandinavian types, and only 12 are American or Asiatic types.

A glance at the map for the position of the Spitzbergen group will enable the reader to realise more fully the interest attached to the investigation of the plants and animals of a small isolated tract of land in so high a latitude—between 76° 33′ and 80° 50′—especially when told that the highest point at which flowering plants have hitherto been seen is about 82°, or within 8° of the pole, in Smith's Sound. The geological formation of the group is of the earliest. So far as at present known it consists of granite and other crystalline rocks, and in the south traces of the Carboniferous and Permian strata have been discovered. The climate of Spitzbergen is modified to a certain extent, like the whole of Western Europe, by oceanic streams flowing from the hot regions northwards. Nevertheless, it is exceedingly rigorous, as may be imagined from the fact that the sun never rises more than 37° above the horizon, and the winter is of ten months' duration. From the observations of Phipps, Parry, Scoresby, and several foreign explorers, the mean temperature of July, the warmest month, has been estimated at about 37° Fahr., and the highest point observed by Scoresby was 51° on the 29th of July, 1815. The mean temperature of the year is about 17° Fahr., and the mean temperature of the three winter months (Dec., Jan., and Feb.) is calculated at about zero of Fahrenheit. Of course the preceding figures must be treated as very rough approximations only.

From the foregoing brief sketch of the climatal and other conditions of Spitzbergen, a very limited number of flowering plants would be expected to thrive, but at least one hundred species have been observed—a comparatively rich flora, when we consider that it is only in the most favourable situations that they can exist at all. Nearly the whole of the vegetation consists of herbaceous perennials, about one-third being grasses, sedges, and rushes. The nearest approach to woody vegetation are the crowberry (*Empetrum nigrum*), two species of willow (*Salix reticulata* and *S. polaris*), and *Andromeda tetragona*, an Ericaceous under-shrub, neither of which rises more than a few inches above the soil. Taking the families in their natural sequence, we have—1. Ranunculaceæ: six species of Ranunculus, and probably seven, a fragment in the Kew Herbarium, collected by the Rev. Mr. Eaton, appearing to be *R. acris*. 2. Papaveraceæ: *Papaver nudicaule*, a pretty dwarf yellow-flowered poppy. 3. Cruciferæ: about eighteen species, including *Cardamine pratensis*, ten species of *Draba*, and one species of scurvy grass, *Cochlearia fenestrata*, perhaps the only esculent vegetable found in Spitzbergen, which has proved most valuable to the crews of the vessels that have touched there. 4. Caryophylleæ: about a dozen species, including the following British—*Silene acaulis*, *Arenaria ciliata*, *A. peploides*, and *A. rubella*. 5. Rosaceæ: four species of *Potentilla* and